# CLAIMS

What is claimed is:

**1.** A fiber lens, comprising:
a graded-index lens;
a single-mode fiber disposed at a first end of the graded-index lens; and
a refractive lens having a hyperbolic or near-hyperbolic shape disposed at a second end of the graded-index lens to focus a beam from the single-mode fiber to a diffraction-limited spot.

**2.** The fiber lens of claim 1, wherein the hyperbolic shape focuses a collimated beam into the diffraction-limited spot.

**3.** The fiber lens of claim 1, wherein the near-hyperbolic shape includes a correction factor that compensates for beam curvature and allows focusing of a non-collimated beam into the diffraction-limited spot.

**4.** The fiber lens of claim 1, wherein a spacer rod is interposed between the refractive lens and the graded-index lens.

**5.** The fiber lens of claim 1, wherein a spacer rod is interposed between the graded-index lens and the single-mode fiber.

**6.** The fiber lens of claim 1, wherein a mode field diameter of the spot is less than 10 μm.

**7.** The fiber lens of claim 6, wherein the mode field diameter of the spot is in a range of approximately 2 to 5 μm.

**8.** The fiber lens of claim 6, wherein a working distance of the fiber lens is greater than approximately 5 μm.

**9.** The fiber lens of claim 6, wherein a working distance of the fiber lens is in a range from approximately 20 to 60 μm.

**10.** The fiber lens of claim 6, wherein a ratio of distance from a tip of the refractive lens to the beam waist to the mode field diameter at the beam waist is greater than approximately 5.

**11.** The fiber lens of claim 1, wherein a diameter of a core of the graded-index lens is in a range from approximately 50 to 500 μm.

**12.** The fiber lens of claim 11, wherein an outer diameter of the graded-index lens is in a range from approximately 60 to 1,000 μm.

**13.** The fiber lens of claim 1, wherein a relative index difference of the graded-index lens is in a range from approximately 0.5 to 3 %.

**14.** The fiber lens of claim 1, wherein an operating wavelength of the fiber lens is in a range from 250 to 2,000 nm.

**15.** A fiber lens, comprising:
a single-mode fiber; and
a lens disposed at an end of the single-mode fiber;
wherein a mode field diameter at a beam waist of a beam emerging from a tip of the lens is less than 10 μm and a ratio of distance from the tip of the lens to the beam waist to the mode field diameter at the beam waist is greater than 5.

**16.** The fiber lens of claim 15, wherein the lens comprises a hyperbolic or near-hyperbolic lens disposed at an end of a graded-index lens.

**17.** The fiber lens of claim 16, wherein a spacer rod is interposed between the hyperbolic or near-hyperbolic lens and the graded-index lens.

**18.** A method of making a fiber lens, comprising:
splicing a single-mode fiber to a graded-index fiber;
cutting the graded-index fiber to a desired length;
rounding a tip of the graded-index fiber into a hyperbolic or near-hyperbolic shape.

**19.** The method of claim 18, further comprising shaping the tip of the graded-index fiber into a cone or wedge having an apex angle defined by asymptotes of a hyperbola prior to rounding the tip of the graded-index fiber.

**20.** A method of making a fiber lens, comprising:
splicing a single-mode fiber to a graded-index fiber;
cutting the graded-index fiber to a desired length;
splicing a coreless fiber to the graded-index fiber;
cutting the coreless fiber to a desired length; and
rounding a tip of the coreless fiber into a hyperbolic or near-hyperbolic shape.